



## Original Articles

# Conceptual processing is referenced to the experienced location of the self, not to the location of the physical body



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## ABSTRACT

We tested whether an experimentally induced change in the experienced location of the self by means of the Full Body Illusion (FBI) would impact high-level cognitive processing.

In an implicit association task, participants saw a landscape where words, conveying spatial (“Near”, “Far”) or social (“Us”, “Them”) semantic distance appeared either in a proximal or distal position. Words’ “semantic” distance was congruent or incongruent to the words’ spatial position. Participants were asked to classify words’ spatial position. Implicit association judgements were intermingled with sessions of visuo-tactile stimulation, during which participants were touched on their back, while viewing an avatar in the distal position being touched either synchronously or asynchronously. In a control experiment, participants performed the same task while observing a neutral object being touched, as a control.

When subjects self-identified with the avatar presented at the distal position, the facilitation effect of the words’ spatial-semantic congruency disappeared. The congruency effect did not disappear in case of asynchronous stimulation as well as in the control experiment with the object, where no change in self-identification was observed. These results demonstrate that conceptual processing is not referenced to the location of the physical body, but to the experienced location of the self.

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## 1. Introduction

Theories of embodied cognition (Barsalou, 2008; Borghi & Cimatti, 2010; Gallagher, 2005; Gibbs, 2006) suggest the importance of sensory-motor systems and the body for cognition, by positing that our mental processes, even high-level cognitive processes, are situated in and depend on the physical body. In line with this view, the Construal Level Theory (CLT) of psychological distance by Liberman and Trope (2008, 2014) and Trope and Liberman (2010) posits that different aspects of semantic information processing, i.e., spatial, temporal, social and probabilistic reasoning, are processed as referenced to the body. More specifically, these concepts are represented on a common dimension in terms of *psychological distance* from one’s own physical body (Bar-Anan, Liberman, Trope, & Algom, 2007; Liberman & Trope, 2008, 2014). Typical empirical demonstrations of this proposal come from a series of experiments (see e.g., Bar-Anan et al., 2007 and Trope & Liberman, 2010 for a review), whereby participants underwent

an implicit association task during which they were presented with pictures containing spatial depth cues, and words denoting either psychological proximity (“Near”, “Now”, “Us”, “Sure”) or psychological remoteness (“Far”, “Tomorrow”, “Them”, “Maybe”) meaning in different semantic domains. Words were placed either close to the participant’s point of view, or far in the scene. The participant’s task was to indicate as quickly as possible whether the word was located spatially near or far in the scene. Typically, the pattern of responses revealed an interference effect: participants respond faster to words whose spatial location and psychological distance matched (e.g., the word “Near” placed at the proximal spatial location on the scene, congruent condition), as compared to not matching stimuli (e.g., the word “Near” placed at the distal spatial location on the scene, incongruent condition). This effect has been interpreted as a demonstration that words’ meaning for different conceptual domains are automatically and implicitly processed in terms of spatial distance from one’s body (termed “psychological distance”). Usually it is impossible to discriminate between spatial distance from the self and spatial distance from the physical body, because normally the experience of our self is bound to that of the physical body: we perceive our self at the place occupied by the body. This link between the self and the body

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is a central feature of self-consciousness and is captured by the concept of bodily self-consciousness (BSC; Blanke, 2012; Blanke & Metzinger, 2009; Pfeiffer et al., 2013; Vogeley & Fink, 2003). It has been proposed that BSC arises from multisensory integration of body-related signals (Blanke, 2012), suggesting a close link between body-related information processing and self experience.

Although self-experience normally coincides with the location of one's own body in spatial terms, conflicting multisensory stimuli can temporarily alter this spatial unity between body and self. During the so-called Full Body Illusion (FBI; Aspell, Lavanchy, Lenggenhager, & Blanke, 2010; Ehrsson, 2007; Lenggenhager, Tadi, Metzinger, & Blanke, 2007; see also Petkova & Ehrsson, 2008), participants view a video image of their body filmed from behind and projected in front of them, while an experimenter concurrently strokes their back. Viewing and feeling one's own back being stroked synchronously induces changes in BSC, leading to a drift in self-location towards the seen (distant) body and self-identification with the seen body. Such a change does not apply when participants view a neutral object being stroked, instead of their own body.

Such changes in BSC have been shown to be associated with changes in low-level, body related, information processing, such as changes in tactile responses (Aspell, Lenggenhager, & Blanke, 2009), skin conductance responses (Ehrsson, 2007; Petkova & Ehrsson, 2008), pain perception (Hänsel, Lenggenhager, von Känel, Curatolo, & Blanke, 2011; Romano, Pfeiffer, Maravita, & Blanke, 2014) and body temperature (Moseley et al., 2008; Salomon, Lim, Pfeiffer, Gassert, & Blanke, 2013).

Moreover, previous studies in the literature have also demonstrated a link between the sense of bodily self - as manipulated by means of classical body illusions - and high-level information processing. For instance, it has been demonstrated that illusory ownership of a dark-skinned rubber hand (Maister, Sebanz, Knoblich, & Tsakiris, 2013) or virtual body (Peck, Seinfeld, Aglioti, & Slater, 2013) reduces implicit racial bias and changes implicit social attitude towards outgroups. Banakou, Groten, and Slater (2013) showed how illusory ownership for the body of a virtual child is associated with implicit perceptual changes, while the illusory ownership of an invisible body reduces social anxiety responses (Guterstam, Abdulkarim, & Ehrsson, 2015). The general idea underlying these studies is that by changing the similarity between the self and the others through shared multisensory experiences can create a connection between the "low-level" representation of the body and high-level cognitive processing, as for instance social cognition and social-affective processes.

By using patterns of visuo-tactile or visuo-motor stimulation, these studies successfully induced embodiment for a "physically" different body or body part, while manipulating the color of skin of the virtual body part (i.e. the arm, Maister et al., 2013) or of the virtual full body (Peck et al., 2013; see also Maister, Slater, Sanchez-Vives, & Tsakiris, 2015 for a review) as well as the age, sex (Slater, Spanlang, Sanchez-Vives, & Blanke, 2010), body dimension (Banakou et al., 2013) and also presence (embodiment of an invisible body, Guterstam et al., 2015) of the virtual body. Here instead we used the FBI to experimentally manipulate the unity between the physical body and the experienced self and test whether such alteration of BSC would in turn affect higher-level cognitive processes, of which we take semantic processing as a paradigmatic case. More specifically, we hypothesized that altering the experienced location of the self in space through the FBI, which affects the spatial coincidence between the self and the body, would change the reference point to which psychological distance, evoked by words, is computed. We were particularly interested in exploring the presence of such a link in the field of the CLT, since this theory provides a conceptualization of distance of different concepts as anchored to a point of egocentric reference that

normally coincides with the body. Here, by manipulating the experienced spatial unity between the physical body and the self by means of the FBI, we asked whether the egocentric reference for psychological distance coincides with the former or the latter. To test this hypothesis, participants underwent an adapted version of the implicit association task by Bar-Anan et al. (2007), while being exposed to visuo-tactile stimulation either inducing the FBI (synchronous condition) or not inducing the FBI (asynchronous control condition). Participants were presented with a landscape scene in a virtual environment. A word could appear superimposed on the image, either at a proximal or at a distal location, close to where an avatar's body was shown (see Fig. 1). Each word conveyed a concept, which was either congruent or incongruent in terms of psychological distance meaning for spatial ("Near" vs. "Far"; Experiment 1), or social ("Us" vs. "Them"; Experiment 2), dimension with the location of the word on the scene with respect to the participants' point of view. Participants were asked to classify as quickly as possible the spatial position of the word in the scene, immediately following exposure to the FBI. Based on previous results by Bar-Anan et al. (2007), in the asynchronous condition we predicted participants to respond faster to words located at congruent psychological distances from their physical body. Psychological distance, indeed, would be computed as referenced to the location of the self, which, in the case of asynchronous stimulation, overlaps with the location of the physical body, matching the proximal position of the words on the screen. Conversely, when exposed to synchronous visuo-tactile stimulation inducing the FBI, the facilitation due to congruent words in terms of both spatial and social psychological distance should reduce or disappear, as the FBI produces an effect of illusory self-identification with the virtual body, which is placed at the distal location on the scene. This pattern of results would suggest that concepts conveying psychological distance are processed depending on the experienced location of the self in space, more than on the physical location of the body. Moreover, in order to demonstrate that the results at the implicit association task depend on a change in BSC, and were not an effect of shifting spatial attention towards a far location, in Experiment 3 participants performed the same experiment as Experiment 1, with the only difference that, instead of observing the virtual body during visuo-tactile stimulation, they observed a body-sized object of a rectangular shape. It is known that viewing an object being stroked does not induce the same changes in BSC induced by viewing a bodily stimulus (Blanke, Slater, & Serino, 2015; Tsakiris, 2010); thus, such condition should not affect how participants process psychological distance related concepts.

## 2. Methods

### 2.1. Participants

Thirty-six subjects participated in the experiment. Twelve subjects participated in Experiment 1 (seven males, mean age  $\pm$  SD,  $22 \pm 2.9$ ), twelve subjects participated in Experiment 2 (five males,  $22 \pm 3$ ) and the remaining twelve subjects (six males,  $23 \pm 5$ ) participated in Experiment 3. All subjects were native French speakers and they were reimbursed for their time. All subjects were naive to the purpose of these experiments and gave informed written consent. The experiment conformed to institutional guidelines and to the Declaration of Helsinki.

### 2.2. Experiment 1 and 2

#### 2.2.1. Materials

Participants underwent an implicit association task similar to the one of Bar-Anan et al. (2007), adapted to a virtual reality

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